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WAVE MAKING RESISTANCE INVESTIGATION OF SUBMARINE 22 M IN SURFACE CONDITION

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ABSTRACT

This research describes the wave making resistance prediction of submarine 22 m in the surface condition with different level of draft and speed. Thin ship theory was used to get the solution of wave making resistance. Michlet is one of the software that be used to solve this problem. There was eight variations of speed and six variations of the submarine draft. The numerical results for a submarine with the length of 22 m and diameter of 3 m shown variation value of wave-making resistance according to draft variation. The simulation results were found that increasing of speed become bigger wave making resistance in 1.5 m and 1.7 m of draft. In the draft of 2.5 m and 2.7 m have some benefit for wave making resistance in the speed of 14 m/s and 16 m/s. Over-all the results of this paper shown a normal agreement with the results of Michlet code.

KEYWORDS:Submarine, Michlet, Speed & Draft

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Original Article

INTRODUCTION

Many studies were carried out in predicting powering submarine designs. It was one of the important part to get the efficient condition for submarine regarding the power consuming. Generally, Submarines used a diesel engine and battery for the main of the powering system. A diesel engine will be used to the surface/snorkeling operation condition of the submarine. A battery will be used to submerged condition. Both will transfer the energy to the electrical propulsion system and can be made translation motion of submarine. Powering prediction was carried out in wind tunnel experiment to get viscous resistance to depend on fin position variation (Yulianto et all., 2014). In the related research, wave making resistance prediction was be developed using tent function method in mini submarine (Sulisetyono & Yulianto, 2018).

Submarine resistance was very influential in predicting submarine power. It consists of two main resistance components. They were a viscous resistance and a wave-making resistance(Allmendinger, 1990). The viscous resistance can be calculated depending on Reynolds number, wetted surface area, speed, and form factor of body hull. The wave-making resistance can occur when in the surface/snorkeling condition. The wave making resistance can be ignored in the submerged condition at depths greater than five hull diameters (Allmendinger, 1990). Depending on the length of the submarine, wave making resistance has zero value at depths greater than a half of body length (Jackson, 1982).

The Michell integral equation is one of the popular equation to solve the problem regarding wave making resistance (Michell, 1898). It was necessary to modify according to the submerged condition of submarine

operation. In the other method, the Havelock source needs only to be distributed on the body surface and it satisfied the free surface condition and far field conditions automatically (Havelock, 1965).

The purpose of this paper is to investigate the wave making the resistance of submarine using a numerical method. It will be conducted in the surface condition of submarine operation. The effect of speed and draft of the submarine will be investigated due to wave making resistance.

METHODOLOGY

In this research, computational studies will be carried out using software assistance. This research was conducted to identify wave-making the resistance of submarine in surface conditions. The steps in this research can be seen in Figure 1.

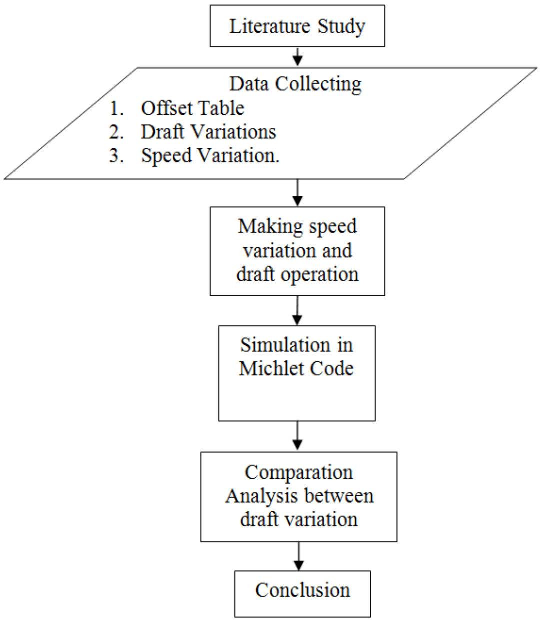

Figure 1: Flowchart of Research Method

Figure 1 shown flowchart of a research method that is used to solve the problem of this research. Firstly, some literature study was carried out for research support. Secondly, Collecting data was done to get offset table of the submarine, draft variation and speed variation. The second step is very importing regarding input of this analysis. Thirdly, Making speed variation and draft operation of the submarine. There were eight variations of speed and six variations of the submarine draft and can be seen in table 1.

Table 1: Varation Speed and Draft of Analysis Condition

Speed Variation	Draft 1.5 m	Draft 1.7 m	Draft 2.0 m	Draft 2.2 m	Draft 2.5 m	Draft 2.7 m
Variation I (m/s)	2	2	2	2	2	2
Variation II (m/s)	4	4	4	4	4	4
Variation III (m/s)	6	6	6	6	6	6
Variation IV (m/s)	8	8	8	8	8	8
Variation V (m/s)	10	10	10	10	10	10
Variation VI (m/s)	12	12	12	12	12	12
Variation VII (m/s)	14	14	14	14	14	14
Variation VIII (m/s)	16	16	16	16	16	16

Fourthly, simulation of wave-making resistance was conducted by using michlet code software (Michlet, 2013). Michlet is one of the numerical software to solve about ship resistance problem. Michlet is a computer workbench that can be used for investigations into some aspects of ship hydrodynamics. Although it is not a ship design program, Michlet can be used for preliminary design work such as estimating the resistance, wave elevation patterns and bottom pressure signatures of monohulls, multihulls and submarines (Michlet, 2013). Michlet can calculate viscous resistance and wave making resistance. Michlet was developed by cyberiad. Figure 2 shown the main view of michlet software.

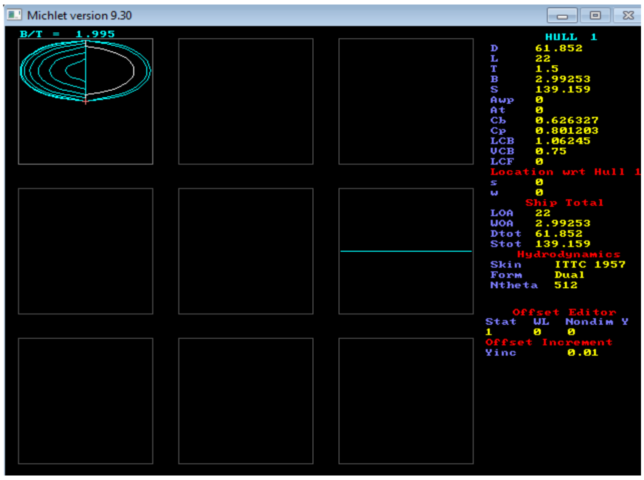

Figure 2: Michlet Code

Finally, Comparison between draft variation will be carried out to get some analysis and conclusion regarding wave making resistance value.

CALCULATION RESULT

The main body hull of submarine consisted of cylinder shape with the length of body hull 22 m, diameter 3 m, and the forebody was hemispherical. In the aft body hull, there was X rudder type for maneuvering supporting. There were two fins stabilizer in the top body hull for supporting in the submerged operation. Figure 3 shown the model of submarine 22 m that be analyzed in this paper research.

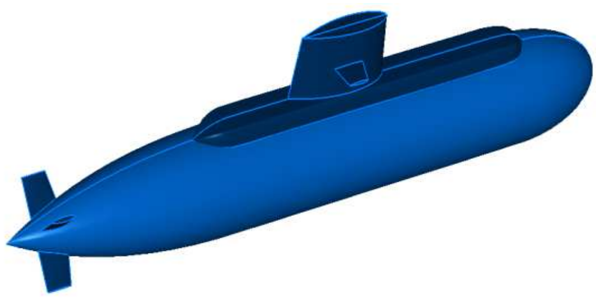

Figure 3: Model of Submarine 22 M

The numerical simulation was carried out in eight variations of speed and six variations of draft operation to get wave making resistance and wave patter. It was compared to the Michlet Code that was developed (Tuck et all., 1999). The numerical results were shown in figure 4. It showed increasing speed due to increasing of wave resistance. In the speed, more than 10 m/s, the wave resistance of submarine only slightly changed comparing with increasing of speed.

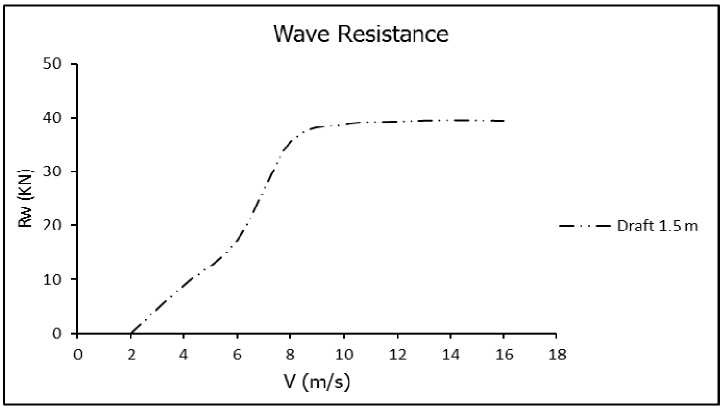

Figure 4: Wave Resistance of Draft 1.5 m

Figure 5 shown increasing of speed due to increasing of wave resistance. In the speed of 14 m/s and 16 m/s, the wave resistance decreased when compared to the increasing of speed. It showed a good condition for submarine operation in the speed 14 m/s and 16 m/s at draft 1.7 m.

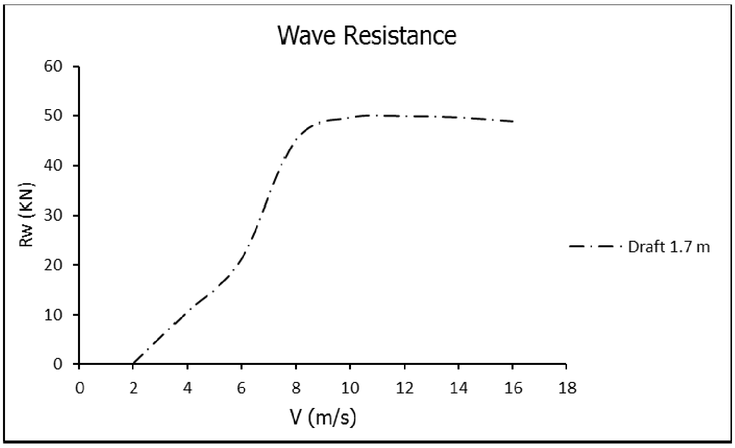

Figure 5: Wave Resistance of Draft 1.7 m

Figure 6 shown increasing of speed due to increasing of wave resistance in the speed between 2 m/s and 10 m/s. In the speed of more than 10 m/s, the wave resistance decreased when compared to the increasing of speed until 16 m/s. It showed a good condition for submarine operation in the speed more than 10 m/s at draft 2.0 m.

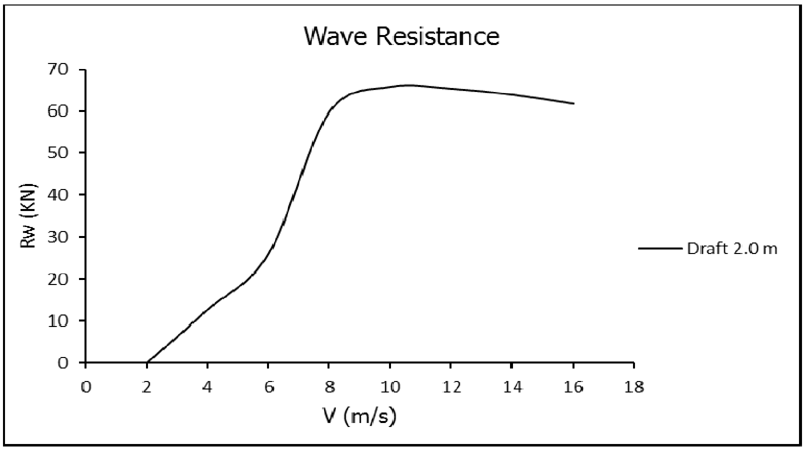

Figure 6: Wave Resistance of Draft 2.0 m

Figure 7 shown increasing of speed due to increasing of wave resistance in the speed between 2 m/s and 10 m/s. In the speed of 10 m/s, It was the highest wave resistance in the draft 2.2 m. And in the speed of more than 10 m/s, the wave resistance decreased when compared to the increasing of speed until 16 m/s. It showed a good condition for submarine operation in the speed more than 10 m/s at draft 2.2 m.

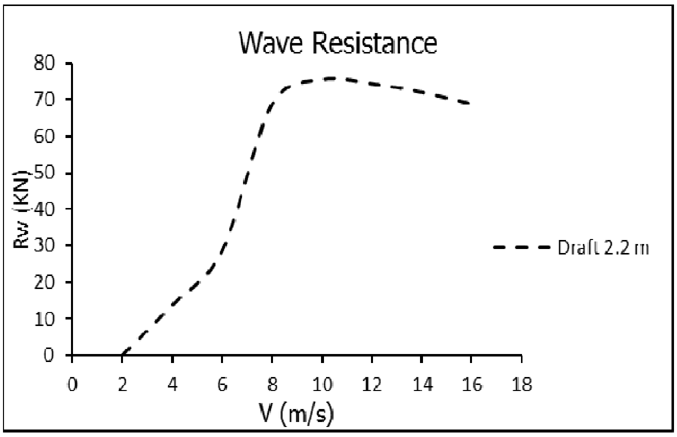

Figure 7: Wave Resistance of Draft 2.2 m

The wave resistance of draft 2.5 m can be seen in figure 8. It showed increasing of speed due to increasing of wave resistance in the speed until 10 m/s. In the speed of 10 m/s, It was the highest wave resistance in the draft 2.5 m. And in the speed of more than 10 m/s, the wave resistance decreased when compared to the increasing of speed until 16 m/s. It showed a good condition for submarine operation in the speed more than 12 m/s draft 2.5 m.

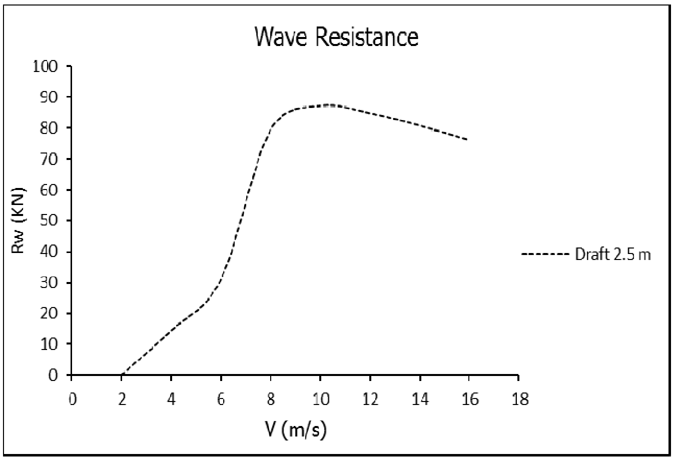

Figure 8: Wave Resistance of Draft 2.5 m

The wave resistance of draft 2.5 m can be seen in figure 9. The highest of the wave resistance happened in the speed 10 m/s. But in the other condition, increasing of speed at greater than 10 m/s due to decreasing of wave resistance. It was a unique case in the operation condition with draft 2.7 m. The submarine operation has more advantages for high-speed operation until 16 m/s in this case study.

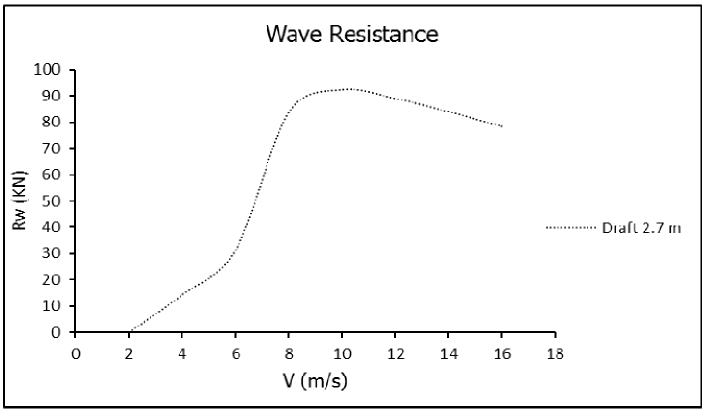

Figure 9: Wave Resistance of Draft 2.7 m

The wave resistance in the variation of the draft can be seen in figure 10. It can be seen a unique characteristic of wave resistance for draft 2.5 m and 2.7 m at speed more than 10 m/s. It showed a significant speed decreasing that will give more advantages for surface operation condition. In the draft 1.5 m and 1.7 m, They have shown increasing of speed due to increasing of wave resistance of submarine.

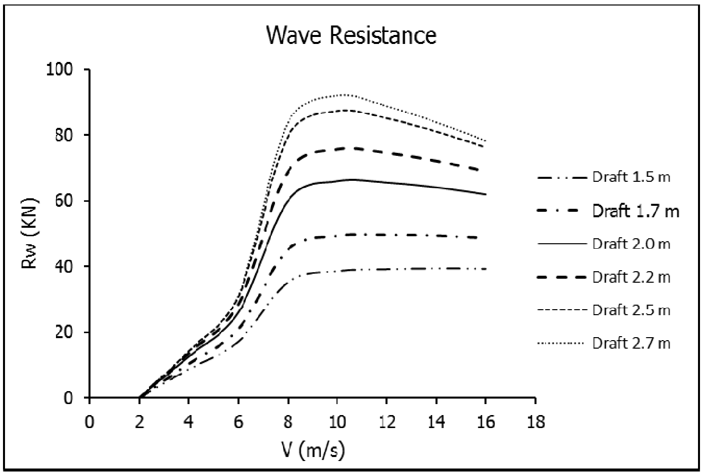

Figure 10: Comparation of Wave Resistance in the Draft Variation

The wave pattern of the submarine in the draft 2.7 m can be seen in figure 11. There are eight wave patterns with eight variations of speed from 2 m/s until 16 m/s. It showed a shape of wave pattern in the variation of speed. Generally, it showed different wave pattern in the each of speed.

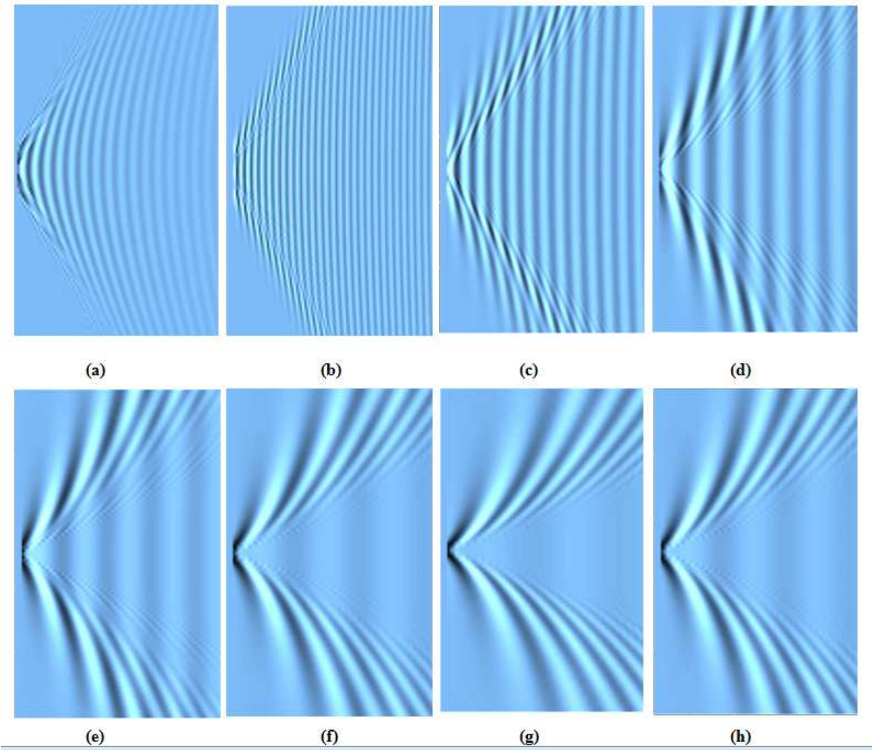

Figure 11: Wave Pattern of Submarine at draft 2.7 m with Speed (a) 2 m/s, (b) 4 m/s, (c) 6 m/s, (d) 8 m/s, (e) 10 m/s, (f) 12 m/s, (g) 14 m/s, (h) 16 m/s

CONCLUSIONS

The simulation results were found that increasing of speed become bigger wave making resistance in 1.5 m and 1.7 m of the draft. But in the draft of 2.0 m, 2.2 m, 2.5 m, and 2.7 m shown decreasing of wave-making resistance in the speed of more than 12 m/s. There were unique characteristics of wave resistance for draft 2.5 m and 2.7 m at speed more than 10 m/s. It showed some benefit for wave making resistance in the speed of 14 m/s and 16 m/s. Overall the results of this paper shown a normal agreement with the results of Michlet code.

ACKNOWLEDGEMENTS

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